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# Hydrometerological Evaluation of Kayauki Area for Granite Mining, Batagarawa, Katsina, North-west Nigeria

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## ABSTRACT

**Aim of Study:** The assessment was carried out to evaluate the feasibility of Granite mining in the area of Batagarawa. This evaluation covered a coordinate of 13°0'28.8" N, 7°43’13.2” E and 13°0'28" and 7°43'6.7" of the area. Aside the geological assessment reflecting its feasibility, the study also aimed to study the positive and negative effects the mining activity is likely to have on the well-being of inhabitants.

**Materials and Methodology:** GPS, sampling bottles, Salinometer, Nessler’s reagent, Colorimetry with molybdenum blue solution, GC-MS, Gravimeter, Atomic Absorption Spectrometer were used for the study. Methodology adopted involved site identification, characterization of the existing environment and development of an environmental management plan. Sampling was designed to capture all the environmental components peculiar to the study area. The spatial boundaries for the field study and sampling was a 600m radius.

**Findings:** The total hardness of the water samples was 39.4, 21.9 and 296 mg/l. Temperature values recorded ranged from 27.9°C-28.5°C. The electrical conductivity was 263µS/cm,160µS/cm, and 799µS/cm respectively. TDS in the water samples of EBQSW1, EBQSW2, and EBQGW were 174, 98, and 566 ppm, respectively. Mean annual sunshine of 3,048 hours, representing 31% of the maximum possible amount of sunlight. Maximum daily temperature of about 400°C and minimum daily temperature of 220°C. The average annual rainfall ranged from 100mm to 300mm in the study area. The average monthly Ultra-Violet index for the study area ranged from 6 to 8.

**Conclusions:** Study concluded that the granite mining is feasible under the prevailing weather condition of the area with more economic benefits that far outweighs the adverse effects.

**Keywords:** Salinometer, Calorimetry, Total Dissolved Solids (TDS), Ultra-violet Index and Spectrometer.

**Article History**

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# 1. INTRODUCTION

Variation in the weather pattern of the study area is crucial for the Environmental Assessment and feasibility of conducting an exploration and production of the granite rocks located in the area for crucial infrastructural development and nation's growth. Climatic variation is currently an important factor that shapes the global community for various projects of great economic benefits to mankind (NIMET 2025). When functional, the plant shall crush large volume of rocks to final usable products, which include stone dust, granite aggregates of various sizes. Climatic variation (Ibrahim et al 2024a) evaluation is thus crucial to most infrastructural development including groundwater production. This will be of great benefit to the actualization of Kano-Maradi Rail line construction to facilitate and enhance economic trade in West Africa sub-region and trade integration especially between Nigeria, Niger, Cameroon and Chad countries. The need for a viable international market between these countries will boost trade, economic prosperity and exchange of great intelligence on security of lives and property among member nations. Much more importantly, this initiative will provide massive amount of direct and indirect jobs to the teaming youths from various communities in the study area. Similar assessment is expected for granite and other valuable raw materials in the upcoming Lagos-Abuja railway project.

Moreso, the area is underlain by basement complex rocks of Precambrian origin. Prolonged weathering of the rocks produced deep clay-rich regolith (Akudo et al 2025). Drilling of pilot holes across the stretch of the rock deposit facilitated reserve estimation. The surface-proven reserve of the granite is about 206,250 tonnes. The planned crushing capacity of 600tph for stone aggregate; the daily output of 1,000 tons on a full operation based on eight (8) hours operation per day. Total output per annum (250 working days, i.e., considering weekends and public holidays) will be 250,000 tonnes/yr. Moreover, (Ibrahim et al 2024), made it abundantly clear that there is great influence on climatic weather variation on groundwater and other infrastructural projects like dams, bridges and roads in recent years and this has been traced to climate change pandemic ravaging the global communities. More importantly, public health of inhabitants will need be safeguarded during the geologic mining (Ibrahim et al 2025) to prevent catastrophic diseases in the area.

# 2. LOCATION

The area in question is located around the coordinate of 13°0'24.16" N and 7°43'0.6" E. Kayauki community, Batagarawa Local Government Area, Katsina State, Northwestern Nigeria.

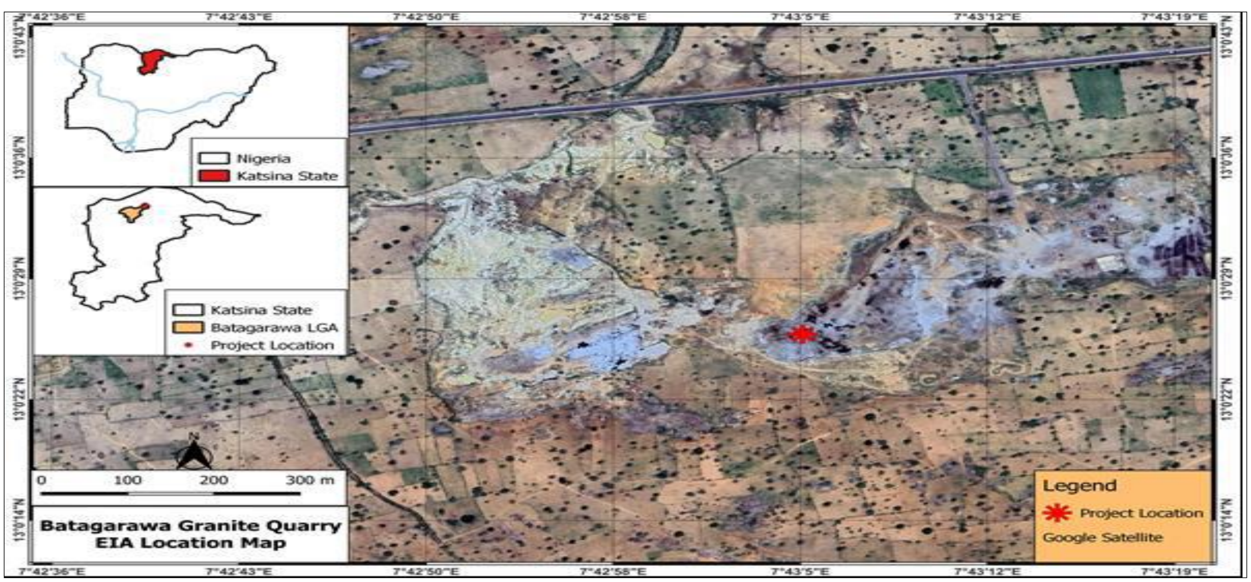


**Fig. 1: Geologic location map of the Kayauki study area**

Electric and hybrid quarry equipment (Adebayo 2012), advanced drilling and blasting techniques with adequate water management are expected to be used in the location which shall ensure optimum maintenance and servicing and hence will enhance the technical sustainability of this project. Generally, sub-surface granite is estimated to be 1,500,000 million tonnes. Therefore, the sub-surface outcrop of the proposed aggregate granite quarry will have a life span of about five years or more depending on the rate of abstraction and production**.** Waste rocks shall be stockpiled away from the quarry pits and protected against storms. They will, therefore be kept for reuse within the site and for community development as backfilling, construction aggregates, drainage/erosion control, landscaping, reclamation and fill materials. Aeromagnetic mapping (Ibeneme et al 2018) of granite in the area will contribute to more discovery of larger deposits.

## 3. TOPOGRAPHY AND ACCESSIBILITY

Topographically a greater part of the area land lies on a naturally high terrain, indicating an external outcrop of the granite material. There are visible pockets of previous mining and a quarry pit has shown evidence of active mining before the site was acquired by another company (Fig. 2), however, the site still possesses a substantial quantity of rock materials to be mined. The approximate area for the granite material is about 0.4 $km^2$. The desired ores are covered with overburden material with thickness that varies within the region. However, some portions of the project area have been exposed due to mining activities. The area is accessible through a decently tarred road linking Katsina and Daura which is about a distance of about 3km Northwest of Batagarawa town, the area's major settlement. However, the closest settlement to the proposed project area is Kayauki, which is about 1.5km to the west.


**Fig. 2: Quarry Pit and Evidence of Mining Activities**

The project is expected to impact Kayauki and Fandare communities, Batagarawa Local Government Area and Katsina State by extension. The immediate communities are more than 1km away from the project sites which is more than 500m radius (buffer zone) required by the Nigerian explosive regulation. Benefits of the work will include provision of granite to support the construction and operation of Kano-Maradi Rail Line, convert the natural resources into usable wealth creation for the inhabitants, youth employment in form of skill and unskilled workforce, improvement on the social amenities in the area eg provision of potable water to the communities that might be impacted with mining activities and much more importantly transfer of new skills of mining activities to the host communities through collaboration and learning. The environmental impacts (Ashraf et al 2015) has shown the area will be feasible for such mining activity pending results from site with low metallic radiation known for similar areas. The mineralogy of the species of granite in the area (Irfan 1996) will give a more comprehensive classification of the granite deposit. 2025 climate forecast (NIMET 2025) is good for mining.

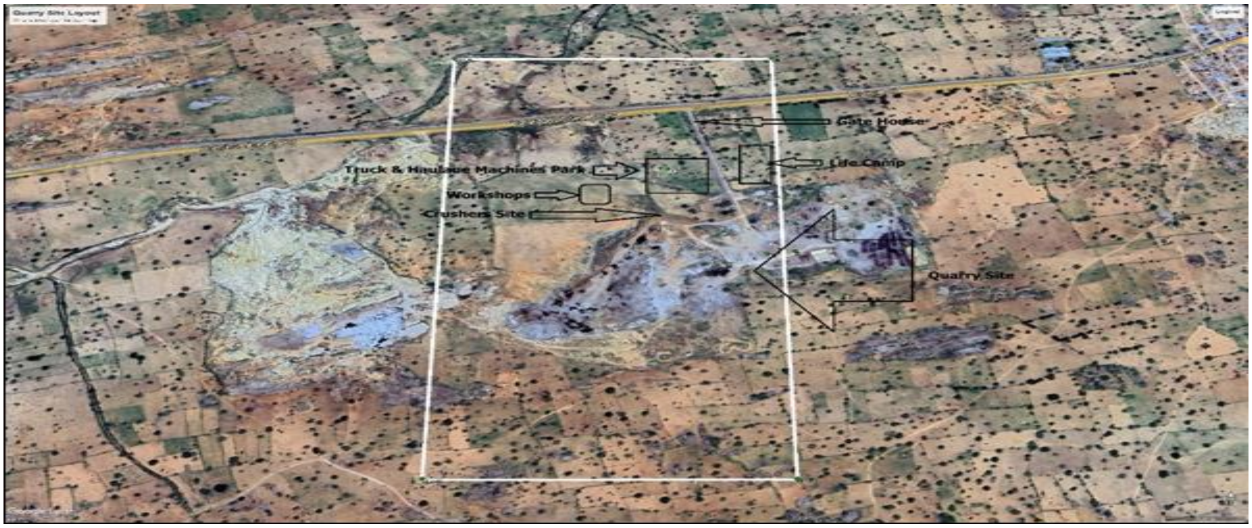


**Fig. 3: Quarry Layout Superimposed on Satellite Image of the Area**

In infrastructure development, rock aggregates are used for a variety of purposes, primarily in road construction, drainage construction, stone masonry, and concreting. Aggregates are made from crushed rock and are categorized as coarse, fine, dust, or powder based on their size composition. For the sake of the proposed project the quarry is designed for more coarse aggregates expected to meet the needs of railway track construction. These quarried materials shall be stored on site before being transferred to the Kano-Maradi rail project site, where the materials is needed for the infrastructural development of the area as previously advanced (Ibrahim et al 2024a).

## 4. MATERIALS AND METHODOLOGY

In general, it included identifying the site, characterizing the current environment, evaluating the project proposal, and creating an environmental management plan. Maps, charts, papers, prior study reports on the area and similar settings in the country, photographs, and a reconnaissance tour to the site were used to identify the topography and pertinent environmental and socioeconomic information on the proposed project area. The information produced made it possible to define the boundaries of the survey region. The primary habitats in the region were grouped and their corresponding sampling needs were clearly outlined using the data acquired from site identification and consultation. This made it possible to gather both quantitative and qualitative data about the region in an efficient manner. The fieldwork conducted included blasting at the blasting zone which entail using drilling materials, compressors, excavators and dump trucks. The rock mass was drilled with a pneumatic crawler drill machine and pneumatic jackhammers capable of producing a drill hole diameter of at least 3 inches depending on the desired explosive consumption and a drill depth of at least 10 m and then charged with high and low explosives in the most efficient method that will create a good fragmentation.

Water samples were collected from 2 quarry pits within the site (Surface) and 1 borehole from Kayauki Community using sterilised bottles. pH values were measured on-site with a pH meter. Temperature and Total Dissolved solids (TDS) were also measured on-site using their respective meters. The sulphates, nitrates and phosphorus analyses were conducted using appropriate test kits, while an Ion Meter was used to detect and analyze compounds such as ammonia. Selected testing properties of the granite deposit in Btagarawa (Joro 2021and Joseph et al 2021) will give more detail data of its more important usefulness.


**Fig. 4: Water sampling of the study area**

## 5. RESULTS

The result obtained from the assessment is hereby presented for further inference on the Environmental Impact study of the area. Results hereby presented represented the field, laboratory and interpretation output of the study area.

### *5.1 Colour*

The water sample appeared colorless. Drinking water gets its color from the absorption of specific wavelengths of ordinary white light by dissolved or colloidally distributed particles. The appearance of color in the water sample could also be due to the presence of metals like iron, manganese, and copper, which are abundant in nature and weathered from the rock as have been similarly reported, or colored organic substances that come from the aqueous extraction or decay of natural vegetation, like in soil runoff (Black et al., 1963). The water samples' obtained true color units (TCU) fall within the aesthetic color objective, which has been set at < 15 TCU (APHA, 1998). For domestic consumption, water should be free from colour and odour. The water sample in the study project area was generally colourless, odourless and tasteless. These characteristics conform with the regulatory limit.

### *5.2 pH*

pH is one of the most common water quality parameters evaluated. It is the negative logarithm of hydrogen ion concentration. By its logarithmic nature, pH is a dimensionless quantity expressed

$pH = - \log [H+]$

Numerous chemical and biological activities in water are impacted by pH. For instance, different organisms thrive in various pH ranges. A range of 6.5 to 8.0 is preferred by the widest variety of aquatic species (Table 1). Because pH outside of this range affects the physiological systems of most organisms and can inhibit reproduction, it decreases the diversity of the stream. Additionally, hazardous substances and elements may become mobile and accessible for absorption by aquatic plants and animals due to low pH. Aquatic life may be poisoned as a result, especially delicate species like rainbow trout. Acid rain, nearby rock, and some wastewater discharges can all contribute to changes in acidity. The pH of the water samples from the study project area was slightly alkaline and fall within the regulatory limit except for the EBQSW2 (Pond water sample water in Kayauki Community), whose concentration was 8.92, thus slightly above the 6.5 to 8.5 (Table 1).

### 5.3 Temperature

Since the addition of hot liquid effluents to water bodies causes excessive temperatures (> 35°C) that change the recipient body's condition in many waters, the temperature of a water sample is the most important parameter to monitor. The photosynthetic action of phytoplankton, the starters of the food chain, is the main food link between fry and fingerlings and the adult fish. High temperatures raise the amount of turbidity and inevitably result in a reduced rate of light penetration. High temperatures cause dissolved oxygen (DO) levels to drop and aquatic species' metabolic rates to increase. Fish growth and reproduction may be hampered by this, and in extreme cases, marine life may perish. Suspended solids settle more quickly at high temperatures (2.5 times faster at 35°C than at 0°C). At higher temperatures, water will also become less dense and viscous. The water samples had reported temperatures between 27.9°C and 28.5°C (Table 1).

### 5.4 Turbidity

A fluid's cloudiness or haziness due to individual particles (suspended solids) that are often imperceptible to the human eye is known as turbidity. Turbidity measurement is an essential water quality test. An optical characteristic of water that has to do with light absorption and scattering is turbidity. Because it influences how much sunlight enters the body of water, it is a crucial parameter. In the aquatic system, their presence results in a high total suspended load, low DO, and a high biochemical oxygen demand (BOD). In addition to lowering visibility, high turbidity directly disrupts autotrophic output. Benthic organisms may be suffocated when particles settle to the bottom due to gravity. Nephelometric Turbidity Units (NTU) are the units of turbidity obtained from a calibrated nephelometer. The turbidity of the water samples was 15.3 and 0 NTU for samples (EBQSW1, EBQSW2 and EBQGW), respectively. Borehole water (EBQGW) has a lower turbidity level compared to the samples from the quarry pit and the community pond. The turbidity level of the quarry pit sample was higher than the regulatory limit as well.

### 5.5 Electrical Conductivity

The particular electrical conductance of water, or the capacity of electric current to flow through it, is referred to as electrical conductivity. The concentration of dissolved solids (mainly inorganic salts) in water is approximately proportional to its conductivity, measured in µS/cm. As a measure of the total amount of dissolved inorganic salts and other substances in water, conductivity is crucial to ecology and environmental management. The water samples' electrical conductivity (EBQSW1, EBQSW2 and EBQGW) was 263µS/cm, 160µS/cm and 799µS/cm respectively. Most underground water contains more dissolved solids than surface water, leading to high conductivity. The permissible Electrical Conductivity level by FMEnv was set for 1000µS/cm. This is also in variance with what was obtained in the Oshin river water of Gbugudu area (Ibrahim et al 2024b).

### 5.6 Total Dissolved Solids

In measurements of milligrams per unit liter of water (mg/L), or parts per million (ppm), total dissolved solids (TDS) are the total amount of mobile charged ions, such as minerals, salts, or metals, dissolved in each volume of water. The relationship between TDS and water's electrical conductivity is as follows: TDS (mg/L) = EC (µS/cm at 25oC) times 0.6 The water samples (EBQSW1, EBQSW2, and EBQGW) had TDS concentrations of 174, 98, and 566 ppm, respectively. Fresh water can be roughly estimated to have a TDS of 1500 mg/l, brackish water to have 5000 mg/l, saline water to have more than 5000 mg/l, and seawater to have between 30,000 and 34,000 mg/l. 500 mg/l is the maximum amount that is advised for drinking water. The borehole water sample recorded a TDS value higher than the regulatory limit as proposed in Kogi (Akudo et al 2025).

### 5.7 Exchangeable Cations

Magnesium (Mg) and calcium (Ca) were the exchangeable cations determined. Calcium causes hardness in water and if present with sulphate may cause boiler scale (GEMS, 1992). The concentrations of ammonium, potassium, magnesium and calcium ion in the water samples (EBQSW1, EBQSW2 and EBQGW) were magnesium (0.9, 0.2 & 4.4 mg/l), ammonium (1.113, 0.694 and 0.326 mg/l) potassium (1.3, 1.0 and 5 mg/l) and calcium (4.8, 3.3 and 21.7 mg/l) respectively. These concentrations were low for all samples except for the ammonium content. EBQGW recorded a high concentration of potassium.

**Table 1:** *Physico-chemical properties of sampled water of the area*

| S/N | PARAMETER | UNIT | SAMPLED PIT WATER | SAMPLED POND WATER | SAMPLED BOREHOLE WATER |
|---|---|---|---|---|---|
| 1 | Latitude | N | 13028.6 | 13057.2 | 1311.6 |
| 2 | Longitude | E | 102974136.7 | 74222.5 | 74228.2 |
| | | | **PHYSICOCHEMICAL** | | |
| 3 | Clear | PtC0U | Clear | Clear | Clear |
| 4 | Odour | | Obourless | Obourless | Obourless |
| 5 | Taste | | Tasteless | Tasteless | Tasteless |
| 6 | pH | - | 7.85 | 7.72 | 8.92 |
| 7 | Electrical conductivity | s/cmμ | 263 | 160 | 799 |
| 8 | Total dissolved solids | ppm | 174 | 98 | 566 |
| 9 | Temperature | °C | 27.9 | 28.5 | 28.5 |
| 10 | Total suspended solids | mg/l | 131 | 59 | 18 |
| 11 | Dissolved Oxygen | mg/l | 2.9 | 3.2 | 4.7 |
| 12 | Turbidity | NTU | 15 | 3 | 0 |

### *5.8 Total Hardness (Carbonate and Bicarbonate)*

In contrast to soft water, hard water has a high mineral concentration, typically composed of calcium ($Ca^{2+}$) and magnesium ($mg^{2+}$) ions, though it may also contain other dissolved metals, bicarbonates, and sulphates. The definition of hard water is "water that does not produce lather with soap solution but produces white precipitate (scum)." The lather test is a straightforward method of figuring out how hard the water is: soap that has been agitated will lather readily in soft water but not in hard water. Water units of ppm or mg/l of calcium carbonate ($CaCO_3$) are used to express the total water hardness, which includes both $Ca^{2+}$ and $Mg^{2+}$ ions. Iron, aluminum, and manganese may also be present at elevated levels in some places, even though we typically assess the overall concentration of calcium and magnesium, the two most common metal ions. The water samples (EBQSW1, EBQSW2, and EBQGW) had respective total hardness values of 39.4, 21.9, and 296 mg/l. The result signifies that the borehole water sample has a high total hardness level above the regulatory limit.

### *5.9 Heavy Metals*

Chemical and physical processes regulate the amount of trace metals in water. Temperature, CO2 level, pH, redox potential, the kind and concentration of accessible ligands and chelating agents, and the kind and concentrations of the metal ions all have an impact on these interactions. From an environmental point of view, trace or heavy metals can bioaccumulate and bio-concentrate in aquatic species. Reduced growth and development, cancer, organ damage, nervous system damage, and, in the worst situations, death are all serious consequences of heavy metal exposure. Exposure to some metals, such lead and mercury, can also result in autoimmunity, a condition where the body's immune system targets its own cells. The concentrations of the heavy metals in the water sample (EBQSW1, EBQSW2, and EBQGW) fall within the regulatory limit except for the concentration of Fe, which was above the regulatory limit across the samples. Heavy metals detection (Li et al 2017) is mandatory for diagnosis as a crucial step of Environmental Impact Assessment.

**Table 2:** *Chemical and Heavy metal properties of sampled water in the area*

| S/N | PARAMETER | UNIT | SAMPLED PIT WATER | SAMPLED POND WATER | SAMPLED BOREHOLE WATER |
|---|---|---|---|---|---|
| | | | **CHEMICAL PROPERTIES** | | |
| 1 | Nitrate ($NO_3^{2-}$) | mg/l | 19.7 | 12.3 | 2.9 |
| 2 | Phosphate ($PO_4^{2-}$) | mg/l | 4.2 | 3.9 | 1.6 |
| 3 | Sulphate ($SO_4^{2-}$) | mg/l | 33 | 12 | 7 |
| 4 | Chloride ($Cl^-$) | mg/l | 5.736 | 5.008 | 0.341 |
| 5 | Ammonium ($NH_4^+$) | mg/l | 1.113 | 0.694 | 0.326 |
| 6 | Calcium ($Ca_2^+$) | mg/l | 4.8 | 3.3 | 21.7 |
| 7 | Potassium ($K^+$) | mg/l | 1.3 | 1.1 | 5 |
| 8 | Total Hardness | mg/l | 39.4 | 21.9 | 296.0 |
| 9 | Magnesium ($mg^{2+}$) | mg/l | 0.9 | 0.2 | 4.4 |
| | | | **HEAVY METALS** | | |
| 10 | Lead ($Pb^{2+)}$ | g/lµ | 0.000 | 0.000 | 0.000 |
| 12 | Mercury ($Hg^+$) | g/lµ | 0.000 | 0.000 | 0.000 |
| 13 | Zinc ($Zn^{2+}$) | mg/l | 0.043 | 2.000 | 1.532 |
| 14 | Chromium ($Cr^{3+)}$ | mg/l | 0.004 | | 0.000 |
| | Iron ($Fe^{2+)}$ | mg/l | 1.362 | 1.024 | 0.922 |

### *5.10 Microbiological Characteristics of the Water Samples*

In general, microbiology is the scientific study of living things that are present but invisible to the human sight. Microorganisms play a crucial role in the aquatic ecosystem's primary production and organic matter breakdown by producing a variety of organic and inorganic substances. Bacteria are just as harmful to drinking water as contaminated water. The water samples show the presence of E-coli in samples EBQSW1 and EBQSW2. The total coliform count was 0 Cfu/ml for EBQGW, while EBQSW1 and EBQSW2 recorded 19 and 8 Cfu/ml respectively.

## *6.0 Climatic variation results*

Temperature, humidity, air pressure, wind, precipitation, atmospheric particle counts, and other climatic factors in each area for extended periods of time are all included in the climate statistics. Latitude, elevation, and topography all influence a place's climate, as do the currents in any surrounding bodies of water. The average and normal ranges of various variables, most often temperature and rainfall, can be used to categorize climates. The dry and wet seasons are the two regimes that define Nigeria's climate. The humid maritime air mass from the Atlantic and the north-easterly air mass from the Sahara (the tropical continental air mass) are the two main air masses that pass over the country at different times of the year. A slanting surface where two air masses moving in nearly opposite directions converge is known as the Inter-Tropical Front. The area around this front where the air masses mix to some extent is known as the inter-tropical discontinuity (ITD) or inter-tropical convergence zone (ITCZ). This zone swings north and south with the front, depending on which air mass gains ground over the other. While the northeasterly air mass influences the dry season, the humid maritime air mass causes the rainy season.

The two contrasted seasons—the dry and wet (rainy) seasons—dominate the project area, which is in the tropics. The two predominant air masses that blow across the nation at different periods of the year—the north-easterly air mass of Saharan origin (Harmattan) and the south-westerly humid maritime air mass blowing from across the Atlantic—are what cause the two season regimes. Protecting the residents' health is the main goal of the study (Ibrahim et al., 2023). Below is a compilation of the project area's climate data (Figs. 5–12);

### *6.1 Sunshine*

The project area experiences an average of eight to ten hours of sunshine per day during the dry season and six to nine hours during the wet season. The research area receives 3,048 hours of sunshine on average each year, which is 31% of the maximum quantity of sunlight that can exist in the environment, as shown in Figs. 5 and 6. Sunny days ranged from 31 to 10 days. The lowest sunshine hours and sun day is in August.

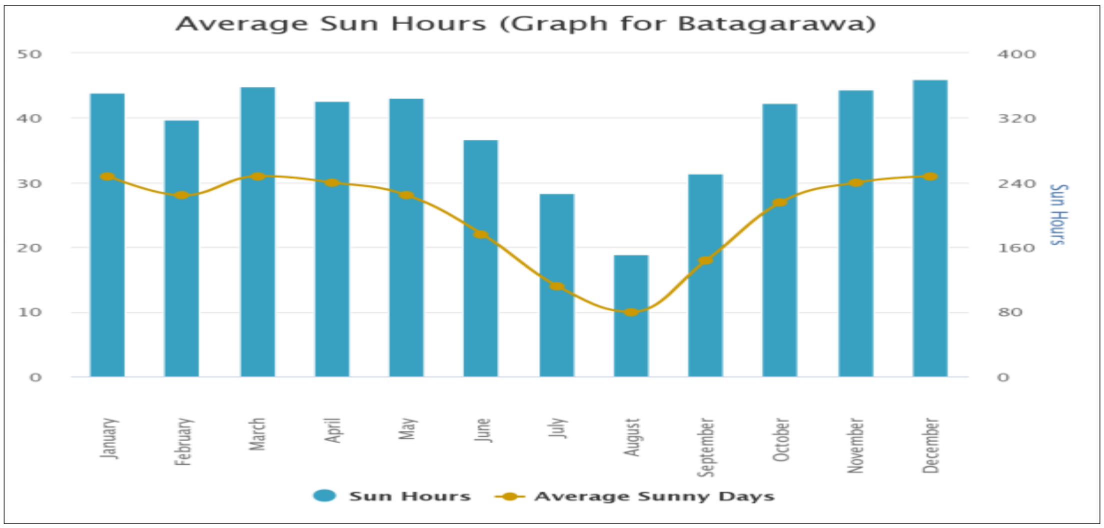


**Fig. 5: Average annual sunshine of the study area**

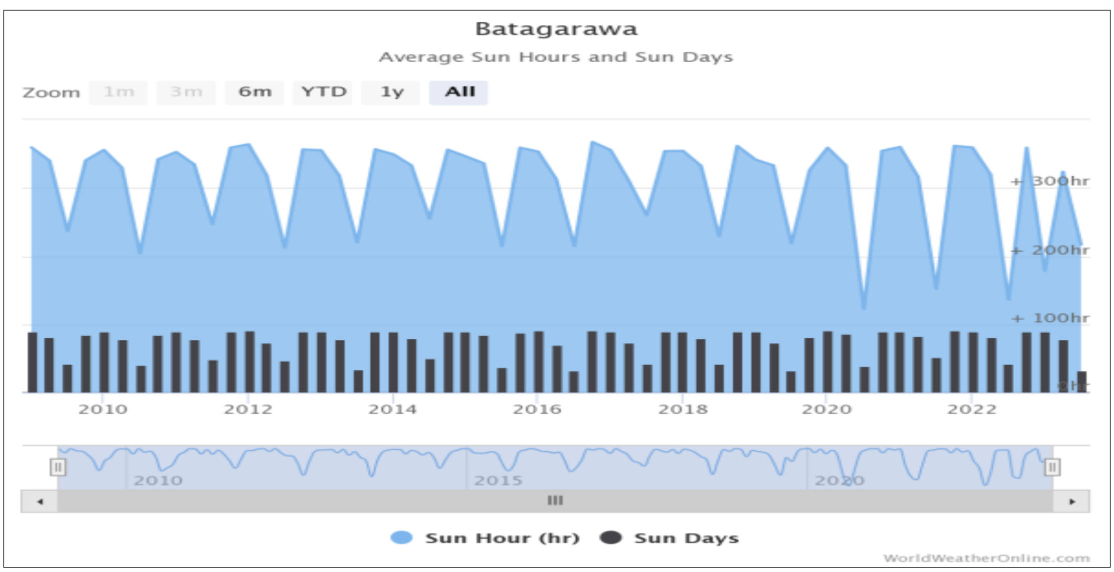


**Fig. 6: Average sunshine hours of the area**

### 6.2 Temperature

The temperature of the area varies with season. Maximum daily temperature of about (400C) and minimum daily temperature of about (220°C) are common. The daily maximum temperature gradually rises from January to its highest value (400°C) in April. It then drops rapidly in August due to heavy clouds and rainfall received. The lowest minimum temperature (15°C) is recorded between December and January each year. This period coincides with the dry, dusty Harmattan winds that blow from the Sahara Desert and at times, reduce visibility to almost zero (Fig. 7).

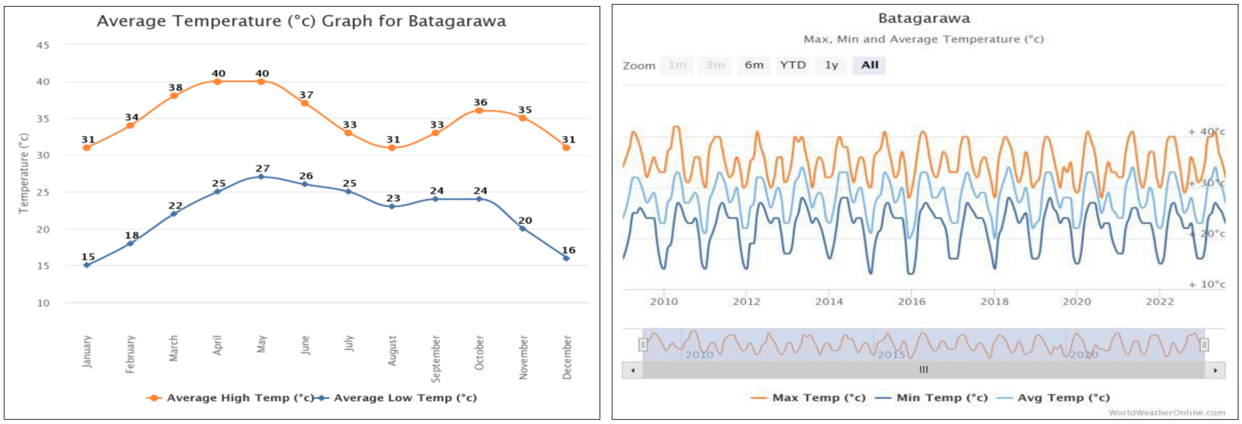


**Fig. 7: Average temperature condition of the area**

### 6.3 Atmospheric Pressure

Pressure is the weight of the earth's atmosphere. There is a substantial correlation between variations in atmospheric pressure and air temperature, water vapor content, and vertical and horizontal air movements. While chilly or cold air decreases, increasing pressure on the air and the earth underneath it, warm air rises and expands relative to its surroundings, lowering pressure locally. The air pressure increased from May to August and then gradually decreased in September. April has the lowest recorded readings, which is consistent with the trend of rainfall throughout that month. The atmospheric pressure fluctuates between 1013.4 mb and 1007.3 mb. The highest average pressure was recorded in 2016, and the lowest in 2014 (Fig. 8).

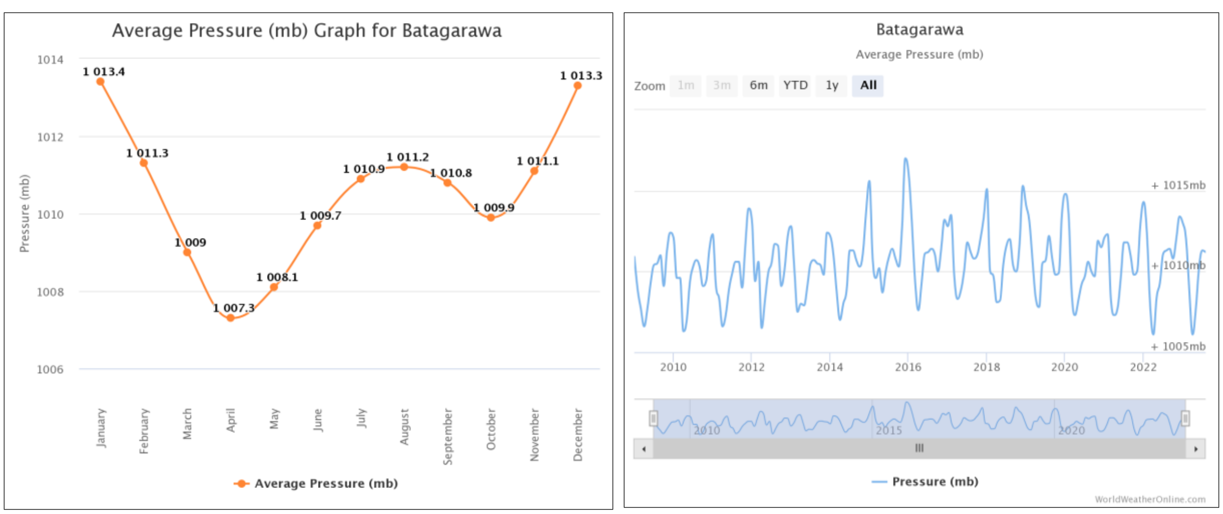


**Fig. 8: Atmospheric pressure of the area**

## *6.4 Relative Humidity and Cloud Cover*

The ratio of water vapor in the air at a given temperature to the greatest amount that the air can contain, represented as a percentage, is known as relative humidity. For example, when the relative humidity hits 100%, it means that the air is saturated with water vapor and cannot hold any more, which makes rain more likely. We base the humidity comfort level on the dew point since it determines whether perspiration will evaporate from the skin and cool the body. You feel more humid when the dew point is higher, and dryer when it is lower.Because dew point tends to move more slowly than temperature, which typically varies substantially between day and night, a humid day typically ends in a muggy night, even though the temperature may decrease at night. In Batagarawa, the perceived humidity varies significantly by season (Fig. 9).

At least 25% of the time during the 5.9-month period from April to October is muggy, unpleasant, or depressing, making it the muggiest season of the year. August is the month with the most humid days in Batagarawa, with 30.7 days that are muggy or worse. In Batagarawa, November and December have the fewest humid days, with 0.0 days that are muggy or worse. The average percentage of cloud cover in Batagarawa varies greatly by season throughout the year. The clearer season, which starts in November and lasts for 3.8 months, finishes in March.With an average of 66% of the sky being clear, fairly clear, or partly overcast, January is Batagarawa's clearest month of the year. The cloudier season, which lasts for 8.2 months till November, begins around March. With overcast or mainly cloudy sky 67% of the time, May is the cloudiest month in Batagarawa. The average annual cloud cover is less than 50%, and the average humidity ranges from 50% to 200%. (Fig. 9).

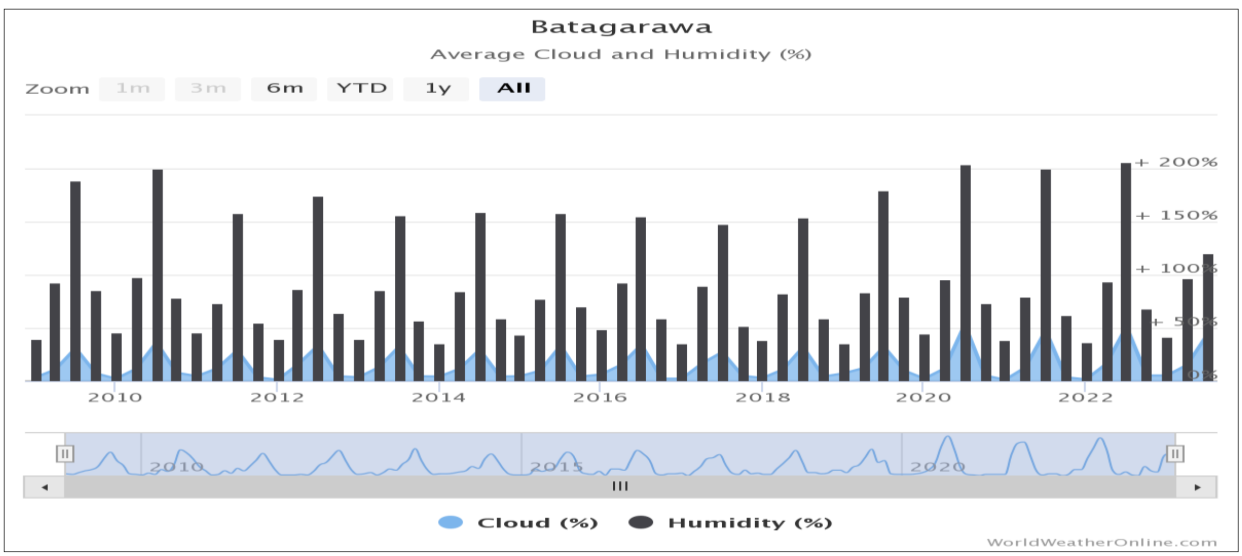


**Fig. 9: Graph of Relative humidity and cloud cover**

## *6.5 Precipitation and Rainfall*

The majority of the rainfall in the study area occurs between May and September, making it a short-wet season. Rainfall occurs every day during this time, despite the fact that it rarely lasts long and differs greatly from the typical torrential rains found in the southern wet tropical regions. In the research area, the typical yearly rainfall falls between 100 and 300 millimeters. The region's climate is dominated by the harmattan wind, which blows Sahara dust across the area, and rainfall typically peaks in August, with little to no rain falling between October and April. Particularly in rural areas with unpaved road surfaces, the dust causes dust disturbance and drastically lowers temperatures by reducing the brightness of the sun.

A day is considered wet if there is at least 0.04 inches of liquid or liquid-equivalent precipitation. The probability of rainy days varies significantly throughout the year in Batagarawa. The 3.6-month wetter season, which spans June to September, is expected to have more than 39% of days with precipitation. August has the most rainy days in Batagarawa, with an average of 23.2 days with at least 0.04 inches of precipitation. September to June is when the 8.4-month dry season occurs.

December has the fewest wet days in Batagarawa, with an average of 0.0 days with at least 0.04 inches of precipitation. August has the most rainy days in Batagarawa, with an average of 23.2 days. With a 77% likelihood of happening in August, rain is the most common form of precipitation throughout the year, according to this classification. Seasons have a significant impact on Batagarawa's monthly rainfall. The 5.6-month rainy season, which lasts from May to October, has a typical 31-day rainfall of at least 0.5 inches. In Batagarawa, August is the wettest month with an average rainfall of 6.3 inches. October to April is when the 6.4-month rainy season occurs. January has the least amount of rain in Batagarawa, with an average rainfall of -0.0 inches. The average annual rainfall is displayed in Figure 10.

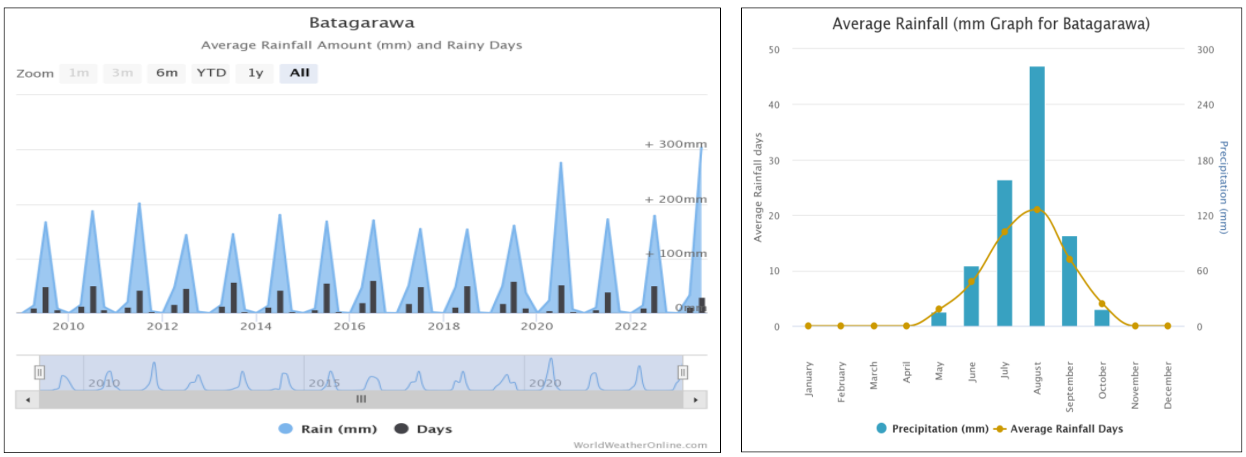


**Fig. 10: Average monthly precipitation and rainfall.**

## *6.6 Visibility*

In the morning, fog forms, reducing visibility to less than 10 kilometers. Morning mist is typically prevalent during the harmattan period, which runs from November to February. Visibility can be as low as 4 miles and stay below 6 miles for several days, making it a serious risk to both aviation and ground transportation. In general, visibility is poor in the morning and gets better throughout the day, especially during the dry season (Fig. 11).

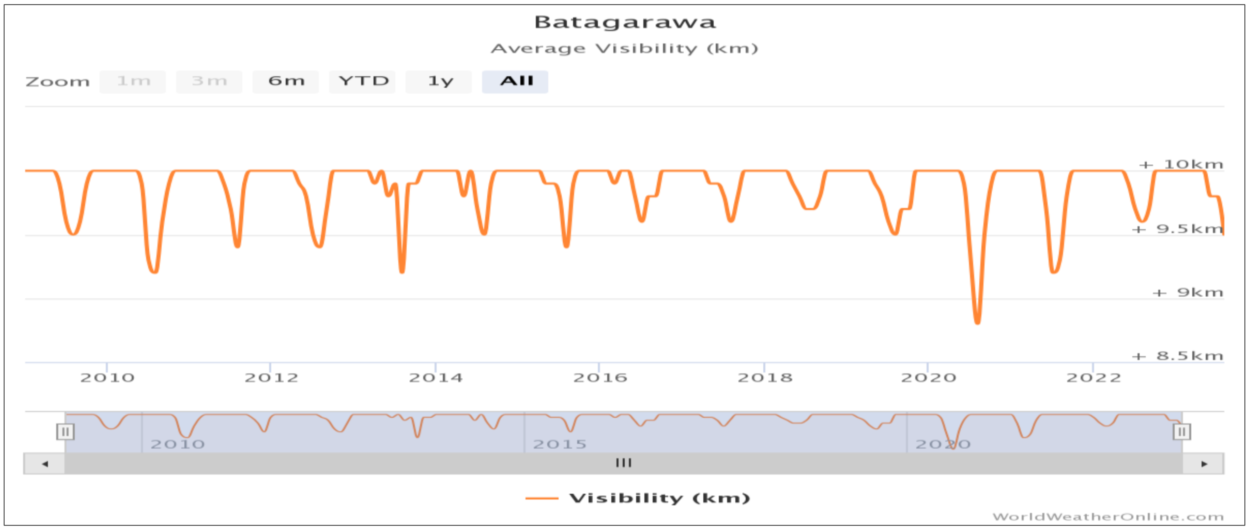


**Fig. 11: Average visibility pattern in the area**

### *6.7 Ultraviolet Index*

The ultraviolet index, also known as the UV Index, is a global standard for determining the amount of ultraviolet (UV) light that causes sunburn at a given place and time. The scale was developed by Canadian scientists in 1992 and was adopted and standardized by the UN's World Health Organization and World Meteorological Organization in 1994. It is generally used in public daily predictions and is becoming more and more accessible as an hourly forecast.The UV Index is an open-ended linear scale that precisely corresponds to the amount of UV light that causes sunburn on human skin. For example, if a light-skinned individual without sunscreen begins to sunburn in 30 minutes at UV Index 6, they may expect to sunburn in around 15 minutes at UV Index 12—twice the UV, twice as quickly (Fig. 12). The average monthly UV index in the project region ranged from 6 to 8 (Fig. 12).

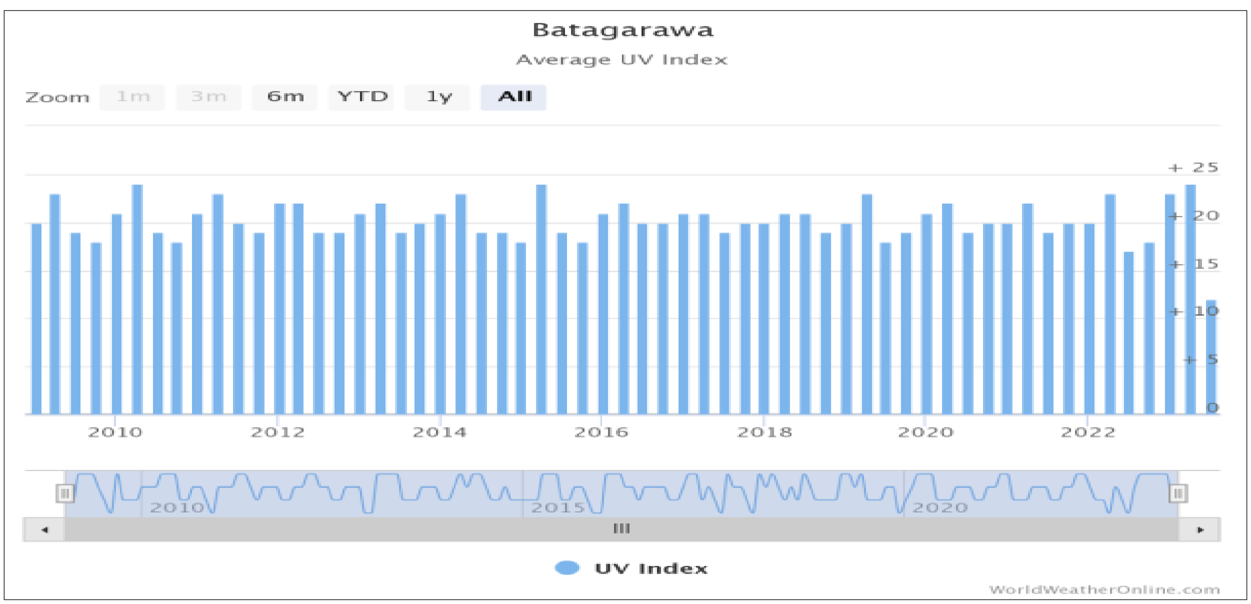


**Fig. 12: Average Ultraviolet Index of the area**

### *6.8 Wind Speed*

Wind speed is the rate at which air passes a specific location. This can be expressed as an instantaneous speed, wind gust, storm, or peak wind speed, or it can be averaged over a specific time period, such miles per hour. On a compass, wind direction indicates the way the wind is coming from, such as the north or west. For tracking and forecasting weather patterns and the global climate, wind direction and speed are crucial. Surface water is impacted by wind direction and speed in several ways. These factors influence the development of seiches and storm surges, surface water mixing, and evaporation rates. The water level and quality are significantly impacted by each of these processes. Numerous circumstances and variables, ranging in size from micro to macro, influence wind speed. These consist of the local weather, Rossby waves and jet streams, and the pressure gradient. Wind direction and speed are related, especially when topography and pressure gradient are involved. A pressure gradient is the variation in air pressure between two points in the atmosphere or on the surface of the Earth. Wind speed is important because the wind travels more quickly to balance the change (from high to low pressure) the larger the pressure differential.

The pressure gradient influences the wind's direction when combined with friction and the Coriolis Effect. The wind experienced at any one location is heavily influenced by local geography and other factors, and the instantaneous wind speed and direction varies more than the hourly averages. The average hourly wind speed in Batagarawa varies greatly by season throughout the year. With average wind speeds exceeding 10 kmph, the windiest season occurs throughout the 7.8-month period from November to July. With an average hourly wind speed of 13.45 km/h, January is the windiest month in Batagarawa. The quietest months are July through November, which lasts for 4.2 months. The calmest month in Batagarawa is September, when the average hourly wind speed is 6.88 kmph. Figure 13 displays the average yearly wind speed, which ranges from 7 kmph to over 20 kmph. Research has demonstrated the many environmental effects of granite mining in a region that may be harmful to the health of local residents (Merian 1994; Mohammed et al. 2019).

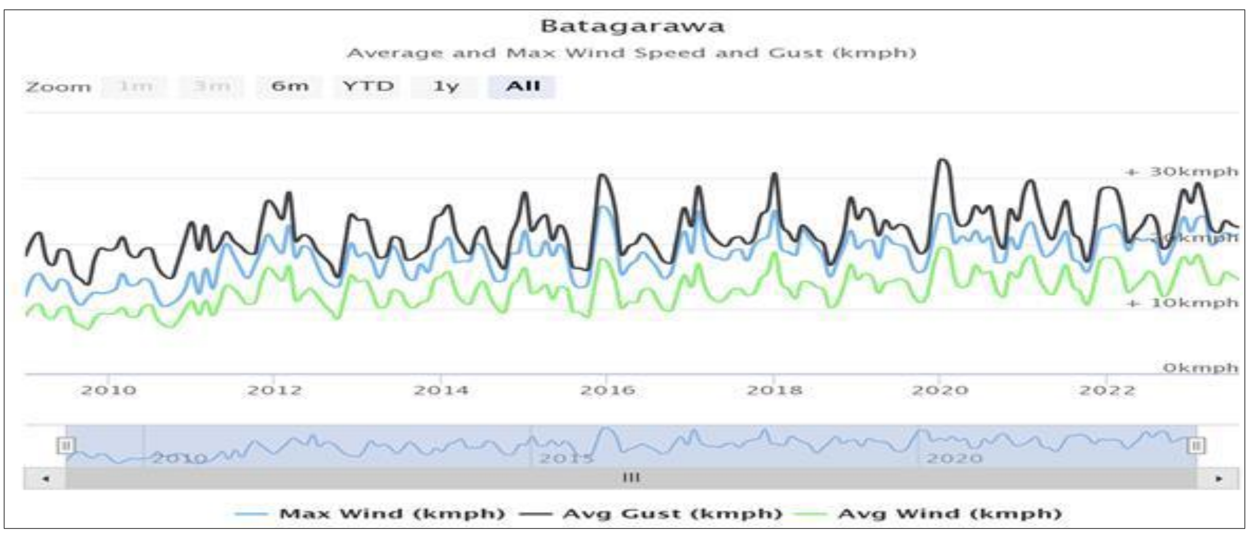


**Fig. 13: Wind speed of the study area**

## 7. IMPACT PREDICTION AND MITIGATION MEASURES

The positive impact of the granite mining in the area is obviously high as it will enhance the socio-economic condition of the area with large job opportunities especially for unskilled workers. It will bring down the cost of building construction in the area as the mined granite is a critical ingredient for construction activities. However, some negative and adverse effects of the activity is that it will affects the serenity of the area with noise and air pollution as operation of equipments and mining activity commence. Landslide is also another common negative effects of this activity. Mitigation measures should include adequate remediation of all mining pits to be restored to the original condition to avoid landslide in the area. Reclamation should include among others use of overburden and topsoil for the reclamation, re-contouring of slopes of more than 300 to minimize run-offs, Contouring of slopes to minimize erosion and run-offs, Planting native vegetation to prevent erosion and encourage self-sustaining development of a productive ecosystem on the reclaimed land. Established bioremediation of the area (Babalola and Ojuederie 2017) is a viable option to reclaim the area for future use. For any organic pollution that might come up in the study area (Gaur et al 2018), remediation of the organic pollutants will be crucial to safeguard the ecosystem of the area. Noise pollution is another critical adverse effect of the (Rim-Rukeh et al 2007) mining activity in the area.

## 8. CONCLUSION

The total hardness of the water samples were 39.4, 21.9 and 296 mg/l with a recorded temperature pattern that ranged from 27.9°C-28.5°C, while electrical conductivity was measured to vary between 263µS/cm,160µS/cm, and 799µS/cm across the three samples respectively, signifying the study area is good for the mining of granite. Moreso, Total Dissolved Solids in the water samples of EBQSW1, EBQSW2, and EBQGW were 174, 98, and 566 ppm, respectively. Mean annual sunshine of 3,048 hours, representing 31% of the maximum possible amount of sunlight. Maximum daily temperature of about 400°C and minimum daily temperature of 220°C. The average annual rainfall ranged from 100mm to 300mm in the study area and finally the average monthly Ultra-Violet index for the study ranged from 6 to 8 have all signified not only the feasibility of such mining activity under a favorable environmental condition but its Geologically plausible as a large granite reserve deposit that can sustain the infrastructural developmental need of a modern rail-way construction that is needed to connect Maradi and Kano in the Northwest Nigeria. Moreso, the mining will enhance the socio-economic activity of inhabitants.

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